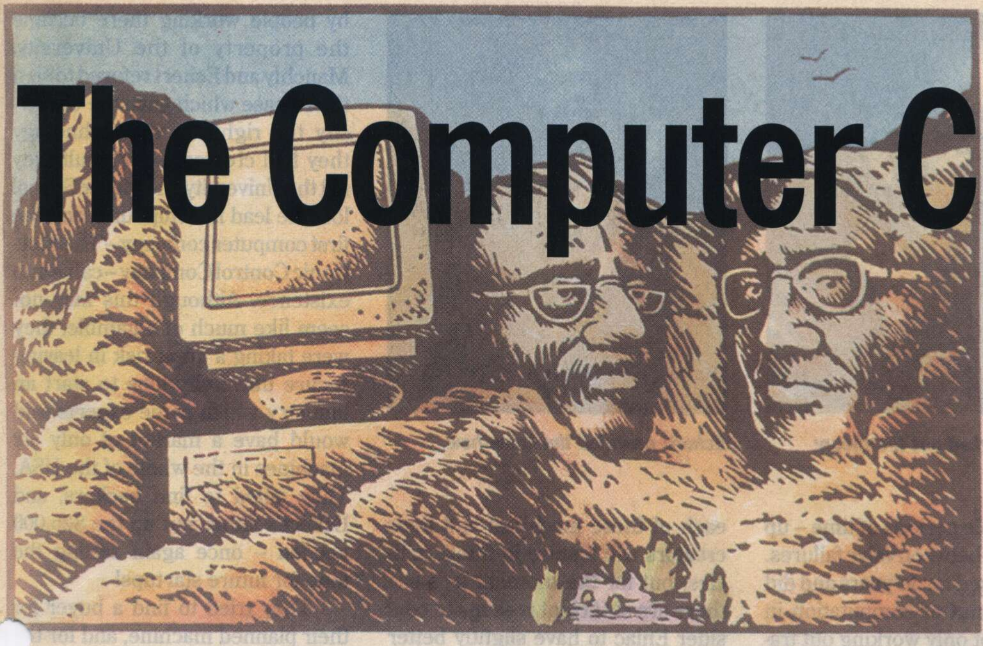
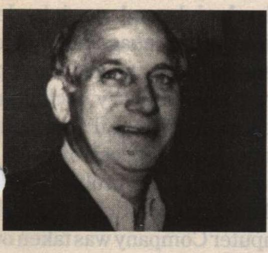
The Computer Creators



Mike James looks at the work of Eckert and Mauchly, pioneers of the electronic digital computer

Who created the first computer? This is the sort of question that children, with their love of certainties and their mania for collecting, often ask. Who was the first to climb Everest? Who invented the diesel engine? In some cases there's a widely accepted answer. However, in the case of the first computer, there's far too much controversy. For example, you can argue about what exactly constitutes a computer. Is there any difference between the first calculator and the first computer? Do you actually have to build the beast, or is just designing it enough for the honour? As soon as you attempt to answer the question of who invented the computer, you start to realise the question itself has little meaning. Some might regard John Presper Eckert and John William Mauchly as the fathers of the electronic digital computer. I would settle for giving them credit as founders of the first computer company. Judge for yourself.

File card: John Presper Eckert/John William Mauchly



John Presper Eckert

Born:	1919
Country:	USA
Specialism:	Engineering
Theories:	None

John William Mauchly

Lived:	1907-1980
Country:	USA
Specialism:	Mathematics
Theories:	None
Products:	Eniac and Edvac
Companies:	The Eckert-Mauchly Computer Company, later taken over by Remington Rand

Some of the elements that led up to Eckert and Mauchly's work have already been described in earlier parts of *The Computer Creators* – Shannon's idea to base computers on binary arithmetic and Von Neumann's invention of the stored program computer are good examples. In 1940, electronics was a very new subject – almost non-existent, in fact.

It wasn't at all clear at the time that the best way to build a computer was to use electronics as opposed to mechanical or electro-mechanical technology. The dominant technologies of the time were mechanical and electro-mechanical, while electronics was high-tech, high-cost and highly unreliable! Any engineer looking for examples of working computers would see pure mechanical devices of high sophistication such as calculating machines, analogue computers and punch card sorting and tabulating machines. Looking further afield, the most advanced systems were the automatic telephone exchanges based on hundreds of relays and uniselectors. It must have seemed a perfectly reasonable plan to build a computer using relays. Indeed, Howard Aiken did just that when he more or less implemented Babbage's analytical engine using around one million components – mainly relays – to create the Harvard Mark I for IBM.

Relays may be reliable, but they are very slow. This is fine for the switching logic of a telephone exchange, but not for a computer. The Harvard Mark I took 0.3 seconds to do an addition, which in today's terms is equivalent to an IBM PC running at a clock speed of 0.000003MHz! Clearly, something a little faster was needed.

The obvious answer was to use valves. At the time, these were used in small numbers as amplifiers and rectifiers in radio and audio equipment, and it was easy to see how they could be used as switches which worked 1,000 times faster than the best relays. But it took at least one valve per logic gate and two for each unit of storage, so you'd need a lot of valves to build even a smallish computer – and valves, like light bulbs, regularly burned out. Any pioneer planning to build an electronic computer was therefore confronted with the prospect of each switch giving only a few seconds of useful computing time before the first valve burned out. Then there were other problems: the huge amount of power needed, the heat generated, and fault-finding in such a huge circuit. Most engineers were familiar with circuits containing three or four valves, while a computer would need tens of thousands!

Even if you were convinced that valves were a good idea, there were other reasons why digital computers might not be the way to go. Most of the useful computation at that time was performed by mechanical analogue machines, and far fewer valves could be used to create a fast and accurate analogue machine than would be needed for a digital machine.

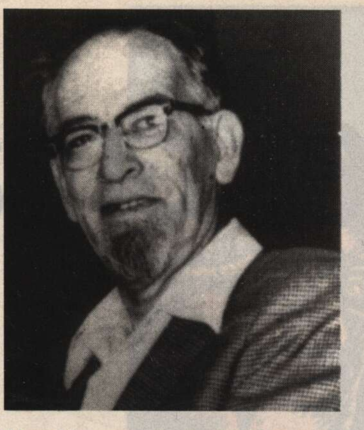
World War II provided the impetus for a great deal of technological development, and computing is a prime example. Aiming a gun may seem to be a simple enough task – just point and fire – but to stand a chance of hitting the target you need to work out the angle that the gun barrel should be set to. This is usually achieved by using a set of 'firing tables', which give the angles needed to hit a target at a given height, allowing for the prevailing wind. The calculation needed to work out a single entry in the table isn't difficult (it's 'A'-level Applied Maths), but working out a full set of tables by hand was taking the US Ballistics Research Laboratory three months, using around 150 people and two mechanical analogue machines. The Laboratory was increasingly falling behind.

In an attempt to catch up, it established a computing substation at the Moore School of Electrical Engineering, University of Pennsylvania. Here Herman Goldstine, the officer in charge, started to talk to Professor John Mauchly, a mathematician, about the possibility of using valves to speed up the process. Mauchly had written a number of papers on using valves for high-speed computation, though it was still thought that an analogue machine might be more practical.

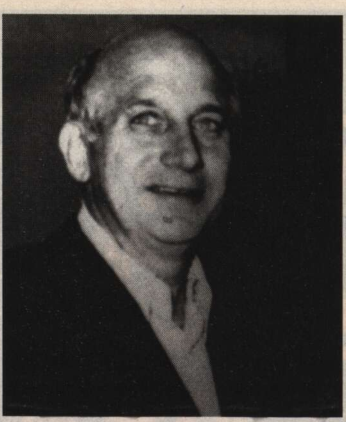
Bigger and better

The difficulties of maintaining accuracy in an analogue machine made digital, for all its problems, seem more attractive. Eckert, an engineering colleague of Mauchly, had some clever ideas about how such a huge collection of valves could be made to work. Together – Mauchly as chief consultant, Eckert as chief engineer, Goldstine as supervisory liaison officer – they started to build an electronic digital computer, which became known as the electronic numerical integrator and calculator (Eniac).

Eniac was started in 1943 and completed at the end of 1945, missing the war by a few months. It was huge, using just short of 18,000 valves arranged in racks 100 feet long in total. It consumed enough electricity for a small town and disposing of the heat produced by the valves was no small problem. But it worked. It could add two numbers in 0.2 milliseconds, and this speed increase enabled previously impossible calculations. In today's terms, Eniac's arithmetical performance is equivalent to an IBM PC running at .005MHz – far better than the relay computers. It even managed to work for reasonable periods of time – up to 20 hours – between valve failures. Eniac was used for 10 years and did a huge amount of computation in that time, not only working out trajectories but running the simulations needed for the H-bomb. It also caught the public imagination, being used in public demonstration to add numbers and plot shell trajectories in real time. It took only 20 seconds to work out the trajectory of a shell that took 30 seconds to reach its target. Eniac's flashing lights and banks of switches set the image in film and fiction that has hardly changed to the present day.



Mauchly: worked out the theory



Eckert: provided the know-how

"In 1946 the US Census Bureau placed the first commercial order for a computer - Mauchly and Eckert's $350,270 Univac"

Eniac differed from a modern computer in a number of important ways. Despite the work of Shannon and others, Eniac used the decimal system to do arithmetic. And it didn't have the internal structure of a modern computer, being more of a collection of logic circuits that could be connected in different ways. It had to be 'programmed' using a plug board and wires that looked like a small telephone exchange, and it could take days to set up a 'program' that would take only a few minutes to run.

So was Eniac the first electronic digital computer? Well, although it could be considered to be the first, this can't be proved. The serious challengers for the title are the Colossus, a secret code-breaking computer built in the UK, and the relay/electronic machines built in Germany by Conrad Zuse. The story of each of these machines and their creators will feature in future articles, but for the moment let's say there are sufficient reasons to consider Eniac to have slightly better credentials than the others.

After Eniac came Edvac, a true stored-program computer. Instead of having to be programmed using plug boards and wires, Edvac stored its instructions along with its data in the way all computers have done since. The idea for a stored-program computer is attributed to Von Neumann as a consequence of his accidental meeting with Goldstine on a railway platform (see *The Computer Creators*, issue 51). But no idea is completely new, and it's possible Eckert had a hand in it.

The biggest problem they encountered in constructing a stored program computer was how to achieve the large amount of memory needed. Using valves was prohibitively expensive, so Eckert suggested using mercury delay lines of the type used to store radar pulses. This indeed proved possible. However, Edvac wasn't the first stored-program computer – Cambridge was completed in 1949, while Edvac wasn't ready until 1952.

Taking the plunge

The strange twist to this story is that Mauchly and Eckert left the Edvac project before it was completed. This was because the University of Pennsylvania insisted that all inventions and patents created by people working there became the property of the University. Mauchly and Eckert refused to sign the release which gave the University the rights to the technology they had created. As a result they left the University, the Moore School lost the lead in computing, and the first computer company – The Electronic Control Company – came into existence. Although this may not seem like much of a gamble, they were taking a great risk in leaving secure university jobs to start an industry which some experts said would have a market of only six machines in the whole of the USA. They failed to find backers, and Eckert's father put up the $25,000 needed – once again setting the tone for future startups!

They tried to find a buyer for their planned machine, and for th second time in the history of computing the US Census Bureau fitted the bill. It had been using Hollerith's punched cards and associated equipment, but punched cards were going to be distinctly impractical for the imminent 1950 census. Keen to use electronics, in 1946 the Bureau placed the first commercial order for a computer – Mauchly and Eckert's universal automated computer (Univac) – at $350,270.

Work began in 1946, but neither Mauchly or Eckert were good managers, so they quickly fell behind schedule and ran into debt. Even so, they managed to find four buyers for their machine and pioneered revolutionary techniques, including digital tape drives for data storage. However, lack of funds remained their main problem, and in 1950 the renamed Eckert-Mauchly Computer Company was taken over by Remington Rand, maker of razors and office equipment. Remington paid $200,000 to Eckert and Mauchly and guaranteed their employment for eight years.

In 1951 the first Univac was delivered, late and over budget. It was the first commercial computer in the US (Leo 1 was produced commercially in the UK in the same year) and, proving the pessimists wrong, various companies ordered a total of 50. Univac became an overnight TV star when it correctly predicted the outcome of the US presidential elections – again proving the pundits wrong. A headline the next day read "Machine Makes Monkey out of Man", and the modern era of computing had well and truly begun. Remington and more or less everyone else were to lose the lead to a late starter, IBM – but that's another story. ■